



FAA-E-2446a  
**May 10, 1971**  
SUPERSEDING  
FAA-E-2446  
17 February 1970

## DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION SPECIFICATION

### TELEVISION MICROWAVE LINK (TML)

#### 1. SCOPE

1.1 Scope.- This specification states the conditions and requirements for furnishing the electronic equipments associated with television relay microwave systems. The equipment and services described herein specify the requirements for a wide-baseband, 14.4-15.25GHz, point-to-point microwave system for relaying a high resolution, scan-converted, composite televised radar display to a remote television monitor.

#### 2. APPLICABLE DOCUMENTS

##### 2.1 FAA Documents.

2.1.1 FAA specification.- The following FAA specification of the issue specified in the invitation for bids or request for proposals, forms a part of this specification to the extent specified herein:

FAA-STD-013	Quality Control Program Requirements
FAA-G-2100/1	Electronic Equipment, General Requirements
FAA-G-1375	Spare Parts - Peculiar
FAA-D-638	Instruction Books, Electronic Equipment

2.1.2 Additional FAA document.- In addition, the following FAA specifications and other documents, of the issue specified in the invitation for bids or request for proposals, form a part of this specification to the extent specified herein:

FAA-E-2360a    Bright Radar Indicator Tower Equipment (BRITE)

2.2 Military and Federal Publications.- The following Military and Federal publications, of the issues in effect on the date of the invitation for bids or request for proposals, form a part of this specification and are applicable to the extent specified herein:

MIL-STD-461	Electromagnetic Interference Test Requirements and Test Methods, June 30, 1966
MIL-STD-778	Maintainability Term and Definitions
MIL-STD-785	Requirements for Reliability Program
MIL-Handbook 217	Reliability, Stress and Failure Rate Data
MIL-STD-470	Maintainability Program Requirements (for Systems and Equipments)
FAA-RD-70-21	ESSA Technical Report - "Rain Attenuation Study for 15GHz Relay Design"
GSA Catalogue	Part III, Hand Tools
MIL-C-25662	Equipment Calibration Standards
MIL-E-17555	Packing and Packaging of Electronic and Electrical Equipment
MS-33586	Dissimilar Metals Specification

2.3 Other publications.- The following publications, of the issue in effect on the date of the invitation for bids or request for proposals, form a part of this specification and are applicable to the extent specified herein:

Electronic Industries Association

RS-195A	Electrical and Mechanical Characteristics for Microwave Relay System Antennas and Passive Reflectors
RS-222A	Structural Standards for Steel Antenna Towers and Antenna Supporting Structures

RS-203	Microwave Transmission Systems
RS-250A	Electrical Performance Standards for Television Relay Facilities
RS-235C	Color Codes for Microwave Devices with Wire Leads
RS-343A	Electrical Performance Standards for High Resolution Monochrome Closed Circuit Television Camera

(Copies of this specification and other applicable FAA specifications, standards, and drawings may be obtained from the Contracting Officer in the Federal Aviation Administration office issuing the invitation for bids or request for proposals. Request should fully identify material desired, i.e., specification, standard, amendment, and drawing numbers and dates. Requests should cite the invitation for bids, request for proposals, or the contract involved or other use to be made of the requested material. Single copies of Military specifications, standards, and handbooks may be requested by mail or telephone from U. S. Naval Supply Depot, 5801 Tabor Ave., Philadelphia, Pa. 19120 (for telephone requests call 215-697-3321, 8 a.m. to 4:30 p.m. Monday through Friday).

Not more than five items may be ordered on a single request; the Invitation for Bid or Contract Number should be cited where applicable. Only latest revisions (complete with latest amendments) are available; slash sheets, such as MIL-E-1/306, must be individually requested. Request all items by document number. For information on subscription service, direct inquiries to the above address with additional marking ATTN. CODE 56, or telephone 215-697-2179, Inquiry Desk.

Requests for information on obtaining copies of FCC Rules and Regulations should be directed to Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

### 3. REQUIREMENTS

3.1 Equipment to be furnished by the contractor.- All equipment shall be delivered by the contractor to the locations specified by the Government and as determined by path surveys. Any item or part required for proper operation in accordance with the requirements of this specification shall be furnished by the contractor even though that item or part may not be specifically provided for or described herein. All necessary facilities, parts, hardware, receptacles, connectors and cabling, wiring, adaptors, and outlets integral to the TML shall be incorporated to enable the composite parts of the system to be properly assembled, and interconnected as required herein. The requirements listed below are described further in the paragraph references noted:

- (a) System survey, paragraph 3.1.2
- (b) System survey reports, paragraph 3.1.2.1
- (c) Instruction books, paragraph 3.3.1
- (d) R/M reports, paragraph 3.3.2
- (e) Installation documents, paragraph 3.3.3
- (f) Microwave RF terminal configured in accordance with the contract schedule, paragraph 3.6.1.1
- (g) Microwave RF repeater configured in accordance with the contract schedule, paragraph 3.6.1.1
- (h) Microwave antenna system and associated hardware as specified in the contract schedule, paragraph 3.6.4

3.1.1 Equipment configuration.- The contractor shall provide microwave radio relay systems and ancillary equipment in accordance with the requirements of this specification, if ordered, configured as follows:

- (a) Simplex system consisting of one transmit terminal and one receive terminal with antennas in accordance with the contract schedule.
- (b) Same as (a) with 100 percent equipment redundancy (hot stand-by) and automatic switching, except for antennas.
- (c) Same as either (a) or (b) equipped for space diversity operation at the receive terminal.
- (d) Repeater terminal for use with systems (a), (b), or (c) and configured for hot stand-by or space diversity operation, if ordered, in accordance with the contract schedule.
- (e) Fault alarm remoting and alarm indicating equipment for use with systems (a), (b), (c) or (d) if ordered, in accordance with the contract schedule.

3.1.2 System survey.- If required by the contract schedule, the contractor shall conduct the necessary path and site surveys and provide the necessary field engineering work for the selection of microwave relay station sites. Survey reports shall be prepared (reference paragraph 3.1.2.1).

Each survey shall be conducted in two phases.

- (I) The survey team performing phase I shall be comprised of contractor personnel. The contractor shall not, during this phase, make contact with land owners unless absolutely necessary. In no case will the contractor personnel make any representations to anyone outside of the Government or the contractor. The Government shall not be represented as a potential buyer or leasee.

The survey team shall select a minimum of three possible site locations for each repeater station required. The site information and description shall be provided to the survey team performing the phase II effort.

- (II) The survey team performing phase II will be comprised of at least one contractor engineer familiar with the area being surveyed, and one or more Government personnel, including a realty officer. The survey team shall select the real estate to be leased by the Government. The Government will make all representations to land owners or their agents. The contractor's engineer shall act in the capacity of advisor and recorder for the phase II survey team.

The contractor shall obtain the requisite information for tower heights and air space requirements and submit to the cognizant FAA office the detailed requirements on an FAA Form 117 for each new station to be implemented.

3.1.2.1 System survey reports.- The contractor shall prepare a survey report at the conclusion of the path and site survey and submit five copies to the Government within 90 days after direction to proceed with Phase I of the survey. System survey reports shall be called the "(System Designation) Microwave Relay System Survey Report. Each station where TML equipment is located shall be assigned a location name. Each report shall contain the following information:

- (a) System layout maps showing site locations, site names, the distance in statute miles between station sites, and the bearing of each individual path between station sites. Detailed information on distance to nearest town, highway(s) identification, etc., shall be provided on separate maps if necessary, in order that sites can be easily located by personnel unfamiliar with the area.
- (b) Site plot layout for each station site showing longitude and latitude of each site, site contour characteristics, elevation, propagation path orientation, location of towers and passive repeaters, estimated length of waveguide runs, and proposed layout of TML equipment in Government-furnished buildings.

- (c) Propagation path profile maps between each site plotted on true earth curvature charts showing critical reflection points and tower heights (center of mounted reflectors or antenna dish) to meet standard clearance requirements.

The path profile shall also show the various clearances required over obstacles for the different equivalent earth radius factors (K).

As a guide, the following Fresnel zone criteria shall be used:

- (1) For  $K = 4/3$ , use 1.0 F
  - (2) For  $K = 1.0$ , use 0.6 F
  - (3) For  $K = 2/3$ , use 0.3 F
  - (4) For  $K = 1/2$  or  $5/12$ , use grazing
- (d) Recommended microwave channel frequency assignments, including antenna polarization.
  - (e) Information stating whether any new facilities will be required for the microwave equipment at each site, or if any existing building is used, what structural alterations to existing buildings are required by the Government to accommodate the installation of the microwave relay system.
  - (f) Possibility of tree growth or future construction at critical points.
  - (g) Possible problems due to paths over water and marshy, flat, or smooth land.
  - (h) Special precautions due to climatic conditions, including diurnal and seasonal variations of the refractive index along the recommended path.
  - (i) Accessibility of site(s) by all weather roads.
  - (j) Availability of electric power.
  - (k) General soil conditions based on surface inspection and other available knowledge of local area.
  - (l) Site obstructions requiring removal.
  - (m) Zoning regulations.

- (n) Regulations regarding airport and airlines.
- (o) Criteria for determining obstructions to air navigation. (Federal Air Regulations, Part 77).
- (p) Alternate site locations also require the information on Items (a) - (p).

3.1.2.2 Review of TML system survey reports by the Government.- TML system surveys shall be conducted as outlined in paragraph 3.1.2. The contractor shall furnish five copies of the preliminary survey report to the FAA's Contracting Officer, at the addresses designated by the Government. If approved, one copy of the report will be returned to the contractor within 60 days. If the report is not approved within that time, the contractor will be advised by the Government of the deficiencies found, based on the requirements of paragraph 3.1.2. The contractor will take steps to immediately correct the deficiencies and resubmit, within 30 days, four copies of the corrected report to the Government for review. An additional 30 days will be used by the Government to review the resubmitted copies.

### 3.2 Definitions.-

#### 3.2.1 Abbreviations.-

TML - Television Microwave Link

NMT - Not more than

NLT - Not less than

R/M - Reliability/maintainability

3.2.2 Bandwidth.- Unless otherwise specified herein, bandwidth shall be measured between the -3 dB voltage levels referenced to the mid-frequency flat, or average response. The mid-frequency response shall be within 1 dB of the maximum bandpass voltage.

3.2.3 Ground.- Less than 0.5 ohms across the signal return circuit.

3.2.4 Open.- Greater than 100 megohms; no voltage shall be present at the contacts except the voltage required to exercise the function.

3.2.5 Hot Standby.- Operation with standby equipment on, but not connected to the antenna system. Antenna switching can be done with waveguide switches.

3.3 Documentation.- The contractor shall provide documentation as specified herein. All documentation produced or updated by the contractor shall show the contract number and date of issue, or revision conspicuously displayed on each document to facilitate identifications and association with the contract. Reproduces or camera copies furnished the Government shall be capable of producing every line and character on the reproduced print.

3.3.1 Instruction books.- The contractor shall provide instruction books and troubleshooting manuals in accordance with paragraph 3.3.1.1 or 3.3.1.2 below, as specified in the contract schedule.

3.3.1.1 FAA-type instruction books.- If ordered, the contractor shall provide instruction books in accordance with FAA Specification FAA-D-638h. Instruction book quantities to be furnished shall be as required by the contract schedule. Copy requirements shall be according to FAA-D-638h.

3.3.1.1.1 Troubleshooting manuals.- Troubleshooting manuals shall be supplied in addition to the regular instruction books. Format, identification, and cover requirements shall be in accordance with FAA-D-638h, except as modified in the following subparagraphs.

3.3.1.1.1.1 Content.- The troubleshooting manuals shall contain all diagrams and illustrations necessary for the isolation and repair of troubles within the TML system. It shall be designed for convenient use by maintenance technicians and shall not contain detailed descriptive information. It shall contain copies of the schematic diagrams, logic diagrams, and system cabling diagrams which are incorporated in the instruction book. In addition, it shall contain simplified, enlarged diagrams of functions designed to aid in the rapid isolation and correction of troubles within the system. Such simplified diagrams shall show separately, in skeleton form, the complete circuitry, such as video signal paths, alarm wiring, etc., showing all test points in each circuit with proper waveform for each test point. Separate wiring diagrams, in skeleton form, shall show and identify each plug, pin, terminal strip, meter, test point, switch relay, etc., for the following circuits: AC power distribution, DC voltage distribution, transmitter high voltage, metering, and other circuits decided upon by mutual agreement between the Government and the contractor. All diagrams shall be arranged to permit simple, straightforward tracing with functions and directions of travel clearly indicated. A table of contents shall be provided.

3.3.1.1.1.2 Construction.- Troubleshooting manual pages shall open flat and be folded. Sheet size shall be 10½ X 21 inches long. Circular (½ inch diameter) holes on ½ inch centers shall be provided along top (hanger) edge of each page. The pages shall be prepared for printing on one side only.

3.3.1.1.1.3 Cover requirements.- Front cover layout shall be in accordance with FAA-D-638h, paragraph 3.9, except:

- (a) The publication number shall be as specified in FAA-D-638h. The vertical centerline of each of the other character groups shall coincide with the centerline of the 10½ X 21 inch cover.
- (b) The horizontal centerline of each character group shall be ½ inch lower, i.e., publication number character group centerline shall be one inch from top of page.
- (c) Hole punching shall be as specified in paragraph 3.3.1.1.1.2 above.
- (d) "Troubleshooting Manual" shall be substituted for "Instruction Book."

3.3.1.1.1.4 Copy requirements.- Copies of the Manuscript Copy Preliminary Manuals (FAA-D-638h, paragraph 3.1.2) and the Preliminary Manuals (FAA-D-638h, paragraph 3.1.3) are not required. Five copies of the Manuscript Copy Final Troubleshooting Manual (FAA-D-638h, paragraph 3.1.4) are required; four of which will be retained by the Government (one copy to the RPCR where assigned, remaining to Contracting Officer); one copy will be returned to the contractor. Printer's copy of Final Troubleshooting Manuals shall be furnished as specified in FAA-D-638h, paragraph 3.1.5.

3.3.1.2 Commercial-type instruction books.- If ordered, the contractor shall provide commercial-type instruction manuals for the TML equipment. Instruction manual quantities to be furnished shall be as required by the contract schedule. Each set of manuals shall include, but not be limited to, the following:

- (a) Description of system operation, including block and level drawings.
- (b) Circuit theory and schematic drawings of modules showing component values, test points, input-output terminals, and a table of replaceable parts.
- (c) Interconnecting chassis wiring diagrams and component layouts.
- (d) Setup, calibration, alignment, and maintenance instructions with step-by-step procedures. Test equipment used shall be that stipulated in paragraph 3.3.6 of this specification.
- (e) Diagrams showing complete wiring arrangement of equipment assembly.
- (f) A recommended preventative maintenance schedule including required daily, weekly, and monthly checks.

3.3.1.2.1 Troubleshooting manuals.- Troubleshooting manuals shall be supplied in addition to the instruction books. The troubleshooting manuals shall contain all diagrams and illustrations necessary for the isolation and repair of troubles within the TML. It shall be designed for convenient use by maintenance technicians and shall not contain detailed descriptive information. It shall contain copies of the schematic diagrams, logic diagrams, and system cabling diagrams which are incorporated in the instruction book. In addition, it shall contain simplified, enlarged diagrams of functions designed to aid in the rapid isolation and correction of troubles within the system. Such simplified diagrams shall show separately, in skeleton form, the complete circuitry of such functions as video signal paths, alarm wiring, etc., showing all test points in each circuit with proper waveform for each test point. Separate wiring diagrams, in skeleton form, shall show and identify each plug, pin, terminal strip, meter, test point, switch relay, etc., for the following circuits: AC power distribution, DC voltage distribution, transmitter high voltage, metering, and other circuits decided upon by mutual agreement between the Government and the contractor. All diagrams shall be arranged to permit simple, straightforward tracing with functions and directions of travel clearly indicated. A table of contents

shall be provided. Troubleshooting manual pages shall open flat and be folded, and sheet size shall be 10½ X 21 inches. Circular (¼ inch diameter) holes on ½ inch centers shall be provided along top edge of each page. The pages shall be prepared for printing on one side only.

3.3.1.2.2 Copy requirements.- Instruction book copy requirements shall be according to FAA-D-638h and troubleshooting manual copy requirements shall correspond to paragraph 3.3.1.1.4 above.

3.3.2 Reliability/maintainability (R/M) reports.- The contractor shall prepare an R/M report containing a complete detailed analysis of the equipment reliability and maintainability, and a summary of the R/M program. An interim report shall be submitted within 90 days after receipt of contract. The final report shall be completed and submitted concurrent with delivery of the first equipment. Requirements for the reliability/maintainability program appear in paragraph 3.7.

3.3.3 Installation documents.- The contractor shall prepare and submit one camera copy and 20 copies of a standard installation document which contains all information pertaining to the installation of the equipment and initiation of its operation. The installation document shall be complete and include applicable data prepared under other documentation requirements of this specification. Submission of these installation documents shall be made 60 days before delivery of first equipment. The Government will review the installation document within 30 days, and the contractor shall incorporate any changes required by the Government. Final documents will be delivered at least 15 days before scheduled delivery of the first equipment. The installation document shall include as a minimum the following items:

- (a) Weight of each equipment rack.
- (b) Dimensions of each equipment rack.
- (c) Outline and configuration drawings.
- (d) Recommended floor plans with alternate.
- (e) Ventilation requirements.
- (f) Physical location of interfacing connectors, including terminal blocks, coax connectors, and waveguide connections.
- (g) Recommended clearance factors for installation and maintenance.
- (h) Power requirements for each primary power input circuit.
- (i) Heat dissipation for each equipment rack.
- (j) Floor loading, in pounds per square foot, of each equipment rack.
- (k) Listing of all equipment supplied by the contractor for a particular site.

- (1) Complete set of installation drawings showing interfacing connectors between racks of the TML, and interfacing with external equipments.
- (m) A list of cables and connectors required for installation, including type, size, function, source and destination.

3.3.4 Test Plan.- A test plan shall be submitted by the contractor meeting the requirements of paragraph 4.0. The objective of this plan will be to show how the contractor will demonstrate compliance with all performance requirements outlined in this specification.

3.4 Construction requirements.-

3.4.1 AC receptacles.- Each rack shall be equipped with two duplex convenience outlets, rated at 20 amps, 125 volts. Each receptacle shall be of the grounding type and shall be installed in accordance with the National Electrical Code. The 115 volt AC branch circuit conductors for the convenience outlets in each rack and the raceway enclosing the conductors shall be terminated in a utility outlet box at the top of the rack. Power for the AC receptacles shall be independent of other power supplied to the rack. Color coding of the conductors shall be in accordance with the National Electrical Code.

3.4.2 Grounding.- For each equipment rack, the AC power return ground, the signal return path ground, and any high noise return path grounds such as those containing transients in high-inductance circuits, shall be separable from each other so that each may be isolated from each other except for system interconnection at a single earth ground for all equipments in the immediate vicinity. No AC power current shall be present in any grounds other than the AC power return. When any ground connection is made to an otherwise painted or finished surface, the paint or protective finish shall be removed at that point so that the ground connection is made to the bare metallic surface.

3.4.3 Accessibility.- The equipment shall be constructed so that each module and subassembly is easily accessible. Each module and subassembly shall be so mounted as to permit its replacement without removal of other modules or subassemblies. Access shall be provided only from the front of each rack.

3.4.4 Deleted.-

3.4.5 Controls, adjustments, and test points.- Controls, adjustments, and test points not specifically identified in this specification, but nevertheless required for proper operation, maintenance, and calibration of this equipment shall be provided. All controls, adjustments, and test points required for maintenance of the system shall be accessible without removing any module or subassembly from the rack. Test points shall be provided to permit failure or malfunction isolation and identification down to the module equipment breakdown level.

3.4.6 Deleted.-

3.4.7 Circuit cards.- Fiberglass circuit cards of .062" minimum thickness shall be used as the basic module board. Circuit cards shall be so constructed as to permit the replacement of components in the field without damage to the boards.

3.4.8 Interconnecting cables.- Cable access shall be provided only through the top of each rack. AC power cables shall enter the rack through a separate threaded conduit, and receptacles or connectors shall be provided for all interconnecting cabling. All cables and connectors interconnecting various racks and assemblies of the microwave system covered by this specification shall be provided by the contractor for adjacent mounted equipment racks. All cables required to interconnect with the external interfacing equipments will be furnished by the Government. All information needed such as connector types, plugs, terminal strips, etc., shall be supplied by the contractor.

3.4.9 Indicating fuseholders.- All fuses or other types of circuit protective devices in the equipment shall be of the indicating type and shall include provisions for connection to an external alarm.

3.4.10 Transient protection.- The equipment shall suffer no damage or degradation as a result of, and shall provide specified performance within five seconds after, being subjected to the following transient conditions for a period not to exceed 500 milliseconds except where otherwise noted:

- (a) Any degree of under voltage.
- (b) Specified voltage or less, at any frequency between 40 and 70 Hz for a nominal 60 Hz supply.
- (c) AC voltage variations of plus or minus 30 percent from any point within the plus or minus 10 percent tolerance band.
- (d) DC input spike test as required in MIL-STD-461, paragraph 6.9.

3.4.11 Reverse Polarity Protection.- Reverse polarity protection shall be provided for DC inputs.

3.4.12 Modularity and Commonality.- The microwave equipment shall be designed with replaceable plug-in modules and printed circuit cards. Functionally identical modules and cards shall be designed to permit maximum interchangeability. All plug-in modules and cards shall be marked as to location and no damage may be incurred from errors in replacement (blowing fuses acceptable). All replaceable components shall be limited to as few different types as possible to simplify spare parts stocking requirements. All components having the same manufacturer's part number

shall be functionally and electrically interchangeable with only minor alignment required using on-site test equipment. All modules and cards shall be provided with test points and shall require no unsoldering or removal of wires in order to remove the modules or cards. The electrical connections on the modules and cards shall be male connectors and coaxial jacks. Modules and cards shall be securely locked in position when in place. Identical modules shall be utilized across the RF band wherever possible.

#### 3.4.13 Materials.-

3.4.13.1 Type.- Metals shall be of the corrosion resistant type or suitably treated to resist corrosion due to fuels, salt spray or atmospheric conditions likely to be encountered in storage or normal service. Unless suitably protected against electrolytic corrosion, dissimilar metals shall not be used in contact with each other. Dissimilar metals are defined in MS-33586.

3.4.13.2 Finish.- The equipment provided under this specification shall be given a finish identical to the contractor's standard line of commercial equipments. If painted, enameled, or laquered, the equipment shall be finished in subdued colors. Bright, flashy colors shall not be provided. Manufacturer's decals shall be of small inconspicuous design and shall be placed where they will not attract attention.

3.4.13.3 Fungus protection.- Materials that are nutrients for fungi shall not be used where it is practicable to avoid them. Where used and not hermetically sealed such materials shall be protected against moisture and fungus with a fungus resistant varnish. Rubber used for "O" rings, gaskets and seals shall be General Electric Class 300 Silicon Rubber or equivalent.

3.4.14 Dimensions.- The microwave equipment shall be contained in one or more standard 19-inch racks not more than 84 inches in height nor more than 24 inches deep. (paragraph 3.6.1.1)

3.4.15 Solid State.- The microwave equipment shall be a solid state design with maximum reliability, maintainability, and operational efficiency. The only non-solid state components permitted in this equipment are indicating lamps, klystrons, and TWT amplifiers. Sole source and screened parts shall not be used without specific approval by the Government.

3.4.16 Ruggedness.- All modules, chassis, circuit cards, drawers, and racks shall be capable of withstanding shipment, bench repair and installation handling without incurring damage to operating controls, meters, test points, and circuitry. All cabling in modules, chassis, drawers, and racks shall be routed, dressed, and laced in accordance with the best commercial practices.

3.4.17 Front Panel Access.- The equipment shall require only front panel access for operation and maintenance. Maintenance shall not require equipment to be turned off, or safety interlocks to be by-passed. All plug-in type circuitry shall be removable from the front on the equipment without the prior need to turn off the microwave system and without causing damage.

3.4.18 Panel Meters and Test Points.- Test points and metering circuits shall be provided for monitoring the performance of the system and for performing maintenance. Provision shall be made for access to all circuit test points required for operation, maintenance, and alignment.

3.4.18.1 Metering.- The parameters to be metered shall include, but not be limited to the following:

- (a) Transmitter output power.
- (b) Transmitter automatic frequency control voltage, as applicable.
- (c) Receiver automatic frequency control voltage, as applicable.
- (d) Receiver automatic gain control voltage, as applicable.
- (e) Receiver mixer crystal currents, as applicable.
- (f) Discriminator Zero Center

3.4.18.2 Test points.- Test points shall be easily accessible and shall be included for the following as a minimum:

- (a) Injection of calibrated RF into each receiver input.
- (b) Calibrated sampling of RF output power from each transmitter.
- (c) Receiver IF output.
- (d) Receiver AGC voltage output.
- (e) DC operating voltages required for maintenance and trouble shooting.

3.4.19 Marking.- All markings shall be clear, concise, legible, and permanent. The radio set, equipment, assemblies, and modules shall be marked with identification as delineated below:

3.4.19.1 Controls and tuning sequence.- All controls and tuning adjustments shall be easily accessible and shall be clearly marked in a manner which indicates their function and enhances ability to adjust the equipment.

3.4.19.2 Components and Modules.- All lamps, switches, fuses, jacks, and test points shall be marked. All other components referenced in the schematic diagrams shall be marked wherever possible.

3.4.19.3 Wiring.- All terminal strips shall have each terminal numbered and all wires leading thereto shall be identified with permanent numbered sleeves, color coding, or equivalent. Each coaxial or multilead cable and receptacle shall be marked with permanent cable band or stencil respectively giving reference designators.

3.4.19.4 Operating frequency.- Transmit and receive frequencies shall be marked on each transmitter and receiver via a write-on decal.

3.4.19.5 Diagrams and charts.- Decals and/or captive plastic encased diagrams and/or charts shall be provided in appropriate places on or adjacent to cards, modules, chassis, drawers, and/or racks to depict the following:

- (a) Tuning/Alignment procedure.
- (b) Normal levels for all test points and meter readings.

3.4.20 Cooling.- Equipment shall be designed to operate over the specified operating temperatures without the use of blowers or other means of forced air circulation or pumped liquids.

3.4.21 Fail safe design.- It shall not be possible to obtain any combination of front panel control settings which shall result in damage to the transmitter, receiver or any associated equipment.

3.4.22 Safety features.-

3.4.22.1 Personnel safety.- All equipment shall be designed so as to prevent injury to personnel or damage to the equipment during installation, operation, and maintenance. Positive consideration shall be given but not limited to the following:

3.4.22.1.1 Low voltage protection.- With the equipment assembled and in operation, personnel shall be protected from contact with potentials in excess of 60 volts to ground, chassis, or frame including potentials on charged capacitors.

3.4.22.1.2 High voltage protection.- Interlocks with an integral by-pass device shall be provided to prevent access to the interior of the equipment, or components thereof, without removal of all voltages exceeding 130 volts peak between any two points of the equipment or between any point and ground. High voltage test points shall be located so as to preclude accidental shock to personnel engaged in normal operation or maintenance.

3.4.22.1.3 High voltage signs.- "Caution High Voltage" signs shall be provided wherever required to warn personnel against shock hazards.

3.4.22.1.4 Connectors.- Unused connectors shall be suitably covered with mating connector jacks.

3.4.23 Workmanship.- The microwave equipment shall be constructed and finished in a thoroughly professional manner. Particular attention shall be given to neatness and thoroughness of soldering, wiring, marking of parts and assemblies, welding and brazing, and freedom of parts from burrs and sharp edges. After final assembly all components shall be thoroughly cleaned of all loose or splattered solder, metal chips, and other foreign material. All surfaces shall be clean and free of smudges, scratches, and other blemishes. All wiring shall conform to the National Electric Code or MIL-STDS and shall be routed, dressed, and laced in accordance with the best commercial practices.

### 3.5 Service conditions.-

3.5.1 Environmental.- The system shall provide specified performance under any combination of conditions of input power specified in paragraph 3.5.2 and any combination of ambient conditions stated below:

	<u>Operating</u>	<u>Storage (Packaged)</u>
Temperature, Degrees C	-10 to +50	-40 to +70
Relative Humidity, Percent	5 to 90	0 to 95
Elevation, Feet	0 to 15,000	0 to 40,000

3.5.2 Input Power.- The equipment shall operate and maintain specified performance when connected to one of the following sources of primary power. The contract will specify the applicable voltage option for each system:

- (a) A direct current power source having an adjustable output voltage from 22 to 28 volts, negative, (positive ground) with ripple and noise NMT 100 millivolts peak-to-peak.
- (b) An alternating current power source having the following characteristics and tolerances:
  - (1) Voltage - 120 volts,  $\pm 10\%$ , single phase, with a variation of up to plus or minus 5% of steady state value.
  - (2) Frequency - 57 to 63 Hz with a variation of plus or minus 1% around the steady state value.

### 3.6 Equipment technical requirements.-

#### 3.6.1 Overall system requirements.-

3.6.1.1 System requirements.- The microwave relay system described herein shall provide broadband transmission facilities capable of accepting and transmitting a radar scan-converted television video signal. The signal will consist of composite horizontal and vertical video information. The composite signal is derived from 945-line, 30 frames/sec. scan converter equipment designated BRITE (FAA-E-2360a). A basic system shall consist of one transmitting terminal and one receiving terminal configured as specified in the contract schedule (paragraph 3.1.1), and shall include power supplies, waveguide elements, branching networks, circulators, alarms, fuse panels, coaxial jackfields or monitors, metering circuits, and other associated equipment as necessary to meet the requirements of this specification. A transmitting terminal shall be contained in a single equipment cabinet, or open or enclosed 19-inch equipment rack not to exceed 84 inches in height; it shall be capable of being expanded to accommodate a second transmitter within the same rack. A receiving terminal shall be contained in a single equipment cabinet, or open or enclosed 19-inch equipment rack, not to exceed 84 inches in height. It shall be capable of being expanded to accommodate a second receiver and diversity switching equipment in the same rack for possible future reconfiguration. A repeater terminal shall consist essentially of a transmit and receive terminal connected back-to-back except that all equipment shall be mounted in not more than two cabinet or equipment racks if diversity or redundancy is specified. Power supply equipment may be located in separate cabinets or racks, one for each terminal or repeater location. Dry air pressurization equipment shall be suitable for rack, wall, or floor mounting as determined by site criteria.

3.6.1.1.1 Frequency interface (VSWR).- The VSWR looking into the RF interface point from the antenna feedline shall be not more than 1.15 to 1 over the band ( $2(Af+fm)$ ) centered on the carrier frequency. The microwave equipment shall provide specified performance when the feedline VSWR measured at the RF interface point is up to 1.2 to 1.

3.6.1.1.2 Frequency separation.- When transmitters and receivers operate into the same waveguide run, each receiver shall provide specified performance when its frequency is separated from the nearest transmit frequency by as little as 150 MHz.

3.6.1.1.3 Baseband accessibility.- The TML shall be designed to permit monitoring of the baseband input signal to each transmitter and the output signal from each receiver. It shall be possible to disconnect the baseband input from either transmitter and the baseband output from its corresponding receiver without disrupting traffic carried over the other path for redundant systems.

3.6.1.1.4 Status and alarm circuits.- Each terminal equipment shall contain sufficient alarms to monitor the terminal operation and indicate malfunctions including power failures. Indicator lamps or meter indications shall be

provided for monitoring critical circuits and for any circuit function required for maintenance, testing, and monitoring. All alarms shall be visual and visible from the front of the cabinet. Any single alarm or any combination of alarms shall also enable a signaling circuit for activation of an external audible alarm (Government furnished). The audible alarm circuit shall be capable of being reset to its off condition by means of a switch. Operation of the audible alarm circuit disabling switch shall not interfere with the normal functioning of the visual alarms. Duplication of alarm circuits shall be required in redundant equipment configurations.

3.6.1.1.5 Alarm remoting and status indicating equipment.- Alarm remoting equipment, if ordered, shall be provided to indicate system and equipment malfunctions at transmit and repeater terminals to a status indicator panel at the receive terminal. The status indicator panel shall meet the requirements of 3.6.1.1.4 for visual and audible alarm indications. The remoting of fault alarms shall not degrade or otherwise interfere with the transmission of the composite video signal (paragraph 3.6.1.2.2.2).

3.6.1.1.6 Patch and transfer panels.- Each microwave transmitter shall be furnished with a video jackfield to provide access to video signals being applied to the frequency modulation generator. By means of the coaxial patch panel, it shall be possible to monitor the transmitter input and at least one other auxiliary input. By means of rigid coax looping plugs, it shall be possible to select the desired input signal for the transmitter from any one of three sources. The coaxial connections and rigid looping plugs shall be designed to provide at least 80 dB isolation to the signal frequencies from outside interference signals. Each microwave receiver shall be furnished with a video jackfield to provide access to video signals supplied from the receiver. It shall be possible to monitor the IF amplifier 70 MHz output signal and baseband signals. By means of rigid coaxial looping plugs, it shall be possible to connect the output baseband signal to any one of three outputs. Coaxial connections and rigid looping plugs shall be designed to provide at least 90dB isolation to desired signals from outside interference signals.

3.6.1.1.7 Waveguide Switches.- Solid state high speed waveguide switches shall be provided where required to permit both manual and automatic switching of the standby transmitter into the antenna waveguide run. Control circuitry shall be included to monitor the output of the primary transmitter and to cause the switching of the stand-by transmitter into its antenna waveguide run, and the switching of the primary transmitter into its dummy load, upon detection of a reduction in a primary transmitter output power below a preset adjustable level. The maximum switching time after the detection of a failure shall be less than 10 microseconds. Switching on a manual basis for maintenance purposes shall not cause a system baseband interruption in excess of 10 microseconds.

3.6.1.2 System characteristics and performance.-

3.6.1.2.1 Operating frequency.-

- (a) The microwave system shall be capable of operating at any frequency in the 14.4 to 15.25 GHz Government band. The use of pretuned or prealigned assemblies, components, and crystals is permissible. The RF equipment shall meet all requirements specified herein after retuning in the 14.4 to 15.25 GHz band.
- (b) To assure compatibility with existing Government RML systems and their frequency assignments, the Government will assign microwave channel frequencies to all TML systems furnished under the contract and the contractor shall adjust each microwave channel to within .005 percent of the assigned frequency prior to the beginning of factory tests. Approved frequency assignments will be supplied to the contractor a minimum of 120 days prior to first equipment delivery.

3.6.1.2.2 Input to output performance characteristics.- With terminals connected back-to-back and with simulated path loss adjusted for normal unfaded received signal level (-35 dBm received carrier level), the system shall exhibit the performance characteristics specified in the following subparagraphs.

3.6.1.2.2.1 Baseband input and output level.- The baseband video input circuit shall be designed to operate with nominal 1.4 volt peak-to-peak input signals and shall be adjustable to accept a range of 0.5 volts to 2.0 volts into 75 ohms, unbalanced. Nominal output drop level shall be  $1.4 \pm 0.4$  volts peak-to-peak into 75 ohms unbalanced and shall be adjustable over a range of 0.5 volts to 2.0 volts.

3.6.1.2.2.2 Composite TV signal level interface to baseband input and output.- The terminal shall meet all specification requirements when interfaced to a composite TV video signal with an amplitude of  $1.4 \pm 0.4$  volts peak-to-peak (composite picture amplitude, alpha plus beta, as defined in EIA Standard Specification RS-343-A). Return loss shall be greater than 20 dB across the baseband. Input and output BNC connectors shall be provided for insertion and drop of baseband signals.

3.6.1.2.2.3 Baseband input-output frequency response.- (end-to-end)

3.6.1.2.2.3.1 Low frequency response.- The low end baseband frequency response shall meet the requirements of EIA Specification RS-250A, paragraph 4.8. Response shall be such that departure from horizontal of top or bottom of a 60 Hz square wave shall not exceed  $\pm 0.5\%$  (1.0% total) of the peak-to-peak test signal amplitude.

3.6.1.2.2.3.2 High frequency response.-

- (a) The system baseband frequency response, input to output, shall be flat to within  $\pm 1.0$  dB from 10 KHz to 12 MHz. Also, the system baseband transient response as determined by the 1T sine-squared pulse and bar signal as described in EIA Specification RS-250a shall not exceed a K rating factor of 1% ( $K = 0.01$ ).
- (b) As an alternate, if required by contract schedule, the system baseband frequency response, input to output, shall be flat to within  $\pm 1.0$  dB from 10 KHz to 16 MHz. Also, the system baseband transient response as determined by the T/2 sine-squared pulse and bar signal as described in EIA Specification RS-250a shall not exceed a K rating factor of 1% ( $K = 0.01$ ).

3.6.1.2.2.4 Differential gain.- The differential gain across the baseband shall not vary by more than  $\pm 0.5$  dB when measured in accordance with the methods recommended in paragraph 4.12 of EIA Standard RS-250a. Tests shall be made at 10%, 50%, and 90% APL.

3.6.1.2.2.5 Video signal-to-noise ratio.- The video signal-to-noise ratio peak-to-peak signal to RMS noise shall be at least 58 dB for normal path conditions.

3.6.1.2.2.6 Video signal-to-hum ratio.- The video signal-to-hum ratio, peak-to-peak signal to peak-to-peak hum, shall be at least 49 dB.

3.6.1.2.2.7 Minimum usable received signal level.- The minimum usable received signal shall be the RF input signal level at the waveguide input flange to the receiver before preselection filtering required to produce a signal-to-noise ratio (peak-to-peak signal to rms noise) of not less than 12 dB measured at the specified baseband bandwidth. This received signal level shall be -75 dBm or lower. Pre- or de-emphasis video weighting networks for a 945-line scanning rate may be used to meet this requirement.

3.6.1.2.2.8 Dynamic range.- The receiver circuitry shall provide an RF dynamic range to the receiver from the minimum level defined in paragraph 3.6.1.2.2.7 up to at least -24 dBm without degradation of system performance (3.6.1.2.2.3 - 3.6.1.2.2.6).

3.6.1.2.2.9 Test tone variation.- Variation in the level of a test tone passed through two terminals back-to-back shall not exceed  $\pm 0.5$  dB over a period of 90 days. Variations in baseband output test tone level due to variation in received signal level between -75 dBm and -24 dBm shall not exceed 0.5 dB. Variation due to changing environmental and input power conditions, as specified herein, shall not exceed  $\pm 0.5$  dB.

3.6.1.2.2.10 Linearity.- System baseband linearity shall be within  $\pm 1.0$  percent when portrayed as a function of peak deviation.

3.6.2 Transmitter characteristics.

3.6.2.1 Frequency range.- The transmitter shall operate at any frequency in the range of 14.4 to 15.25 GHz.

3.6.2.2 Modulation.- The transmitter shall be frequency modulated.

3.6.2.3 Frequency deviation.- The deviation produced by a nominal reference level video signal shall be that necessary to produce the required baseband frequency response without distortion.

3.6.2.4 Frequency stability.- The center frequency of the transmitter shall not vary more than plus or minus 750 KHz from the assigned frequency over a period of 90 days without realignment, over the total temperature range stated elsewhere in this specification. This stability shall be obtained within 15 minutes after the application of prime power.

3.6.2.5 Spurious emission.- Spurious emission from the transmitter shall be down not less than 60 dB referred to unmodulated carrier level at the transmitter assembly waveguide output flange to the antenna over the band of 14.4-15.25 GHz. A load isolator shall be provided between the output device and transmitter waveguide bandpass filter.

3.6.2.6 Transmitter output power.- Transmitter output power as measured at the output waveguide flange to the antenna shall be as specified in either (a) or (b) below in accordance with the contract schedule:

- (a) A minimum of +27 dBm using a klystron or solid state amplifier as the final power amplifier.
- (b) A minimum of +37 dBm using a solid state modulator driver amplifier followed by a traveling wave tube final amplifier.

For (b) version transmitter, the traveling tube amplifier and associated power supplies shall have a guaranteed in-service minimum life of 8,000 hours.

3.6.3 Receiver characteristics.

3.6.3.1 Frequency range.- The receiver shall operate at any frequency in the range of 14.4-15.25 GHz.

3.6.3.2 Frequency stability.- Frequency stability shall be that specified in 3.6.2.4. The local oscillator shall track the incoming frequency by means of AFC. The local oscillator shall not lock off frequency on noise or weak interference signals.

3.6.3.3 Image rejection.- The receive image frequency and all other signals removed from the receiver frequency by 100 MHz or greater shall be rejected by at least 60 dB at the nominal RF received signal level.

3.6.3.4 Receiver noise figure.- The receiver noise figure shall not exceed 10.5 dB measured after the receiver preselector. Preselector losses shall not exceed 2 dB.

3.6.3.5 Local oscillator leakage.- The receiver local oscillator leakage as measured at the RF interface point shall not exceed minus 85 dBm.

3.6.3.6 AFC capture range.- The receiver Automatic Frequency Control (AFC) circuitry shall be such that the receiver will not lock onto any received signal offset from the assigned RF carrier frequency by 7 MHz or more at an input level of minus 75 dBm at the RF interface in the absence of any received signal on the assigned frequency.

3.6.3.7 Frequency tolerance.- The receiver shall deliver specified performance when the input RF signal varies from its assigned frequency by plus or minus 750 KHz. Frequency adjustment of the receiver to meet the performance requirements stated herein shall not be required more often than once every 90 days.

3.6.3.8 Receiver Squelching.- Microwave receivers shall be equipped to provide automatic squelching action during any conditions of high receiver noise output. Squelching to provide a noise-free baseband output shall occur for video signal-to-noise ratios of peak-to-peak signal to RMS noise of 12 dB or less.

3.6.4 Antenna system requirements.- Each antenna system item furnished by the contractor shall be commercially produced equipment of proven design and shall have as a minimum, the main and required characteristics listed in the following subparagraphs.

3.6.4.1 Microwave antenna.- Microwave antennas shall be four or six foot diameter parabolic antennas. The microwave antenna shall consist of a paraboloidal reflector and a feed system capable of producing the required electrical characteristics. The radiator shall be plane polarized and shall be adjustable throughout 360° with respect to the reflector. Antenna waveguide flanges shall be UG-419/U or UG-541A/U. The reflector shall be sturdily constructed using any technique which will meet the electrical, mechanical, and environmental requirements of the specification.

3.6.4.1.1 Electrical characteristics.- Microwave antennas shall have the following characteristics as a minimum:

Ant. Size	Ant. Gain Mid-Band	Half Power Beamwidth Mid-Band	First Side Lobe	Wideband Side Lobe	Front to Back Ratio	Max. VSWR
4 ft.	42	1.20	-18	40	45	1.10
6 ft.	46	0.80	-18	42	50	1.10

3.6.4.1.2 Microwave antenna mounts.- Antenna mounts, if ordered, shall be furnished in one or more of the following configurations: (1) Horizontal mount, with three, 120° adjustment bolt assemblies with an adjustment range of +5°. (2) Horizontal tilt mount with elevation adjustment of -5 to +50°. (3) Vertical pipe mount with elevation adjustment of -5 to +50°.

3.6.4.1.3 Environmental conditions.- Radome shielded microwave antennas and mounts shall withstand 100 mph wind, plus 1-inch of radial ice without damage, and shall maintain antenna deflection to less than one beamwidth in 40 mph winds. Unshielded microwave antennas shall withstand 120 mph winds with 1/2 inch of ice without damage. Microwave antennas, antenna mounts, and hardware shall meet or exceed applicable EIA RS-195A and RS-222A recommendations for performance, material, manufacture and workmanship, factory finish, and marking.

3.6.4.2 Radomes.- Heated radomes for four or six foot microwave antennas shall be provided. Radomes shall have the following electrical characteristics throughout the frequency band of 14.4-15.25 GHz.

<u>DIA</u>	<u>Max. Attenuation in dB across the band</u>	<u>Max. VSWR</u>
4 or 6 foot	1.0	1.03

Radomes shall be treated to resist deterioration resulting from exposure to ultraviolet radiation. Heated radomes shall have the heater elements molded into the radome material and shall not require radome polarization alignment. The heater AC power dissipation shall be between 1200 and 1600 watts, and the heater circuit shall be thermostatically controlled by ambient outside air temperature to energize the heaters within the range of -10 and +2 degrees centigrade. The heater circuit shall have a test switch to energize the heaters for test purposes. An indicating lamp circuit shall be provided which will cause a status lamp to light when the heater energizing circuit is closed.

3.6.4.3 Elliptical waveguide.- Continuous semi-rigid formable elliptical waveguide consisting of flexible corrugated copper tubes of elliptical cross section with an outside pressure tight jacket suitable for field installation of waveguide connectors shall be furnished for all waveguide runs external to the equipment terminal.

3.6.4.3.1 Frequency range.- Elliptical waveguide shall cover the frequency range of 14.4-15.25 GHz in one size.

3.6.4.3.2 Bending radius.- The minimum bending radius for repeated bends of elliptical waveguide shall not be greater than 15 inches in either plane.

3.6.4.3.3 Elliptical waveguide connectors.- End connectors for elliptical waveguide shall be provided. Each set (2) of connectors shall include connector hardware as required to mate connector and waveguide. Inter-connection shall not require soldering or brazing. Waveguide/connector joints shall be pressure-tight to 15 psig. The connector flange shall mate with both UG-541A/U and UG-419/U waveguide flanges.

3.6.4.3.4 Electrical characteristics.- Elliptical waveguide with a connector on each end shall have the following characteristics:

<u>Frequency</u>	<u>Attenuation dB per 100 feet</u>	<u>Max. VSWR</u>
14.4 to 15.25 GHz	5.5 or less	1.15

3.6.4.4 Flexible waveguide.- Flanged flexible waveguide to mate with elliptical waveguide connectors and microwave antennas shall be furnished if required. Allowable twist/bend shall be 100° or more per foot. VSWR shall not exceed 1.10 across the band.

3.6.4.5 Miscellaneous hardware.- Elliptical waveguide grounding kits, waveguide bending tools, connector installation tools, elliptical to rectangular transitions, wall/roof feed-thru kits, hanger kits and hanger angle adaptors shall be provided in accordance with manufacturer's specification for installation, spacing, and utilization.

3.6.4.6 Dry air pressurization equipment.- The contractor shall supply waveguide pressurization kits, as required by the contract schedule, capable of delivering a continuous supply of dry air under any climatic conditions. The pressurization kit shall operate from a nominal 120 V, 60Hz power source within the ambient temperature and humidity ranges specified in paragraph 3.5.1, and provide a minimum of 1.0 CFM at 4 psig of dry air. The output air dew-point shall be lower than -37° F. No heating elements shall be used to obtain the required dry air output and automatic reactivation of the drying agents with no unit downtime shall be provided. A meter type pressure indicator calibrated in PSI, air inlet valves, and all other fittings and connectors required for interfacing the pressurization system to up to four waveguide runs shall be provided. Also, 25 feet of polyethylene or similar tubing shall be included with each kit for connection to the waveguide runs. Waveguide pressure windows shall be supplied for each end of the waveguide run in quantities of one pair for each antenna provided under the contract schedule. Pressure window VSWR shall not exceed 1.04. Low pressure and humidity alarm activation equipment and circuitry shall be provided in the form of a short/open of an alarm pair for each alarm. In addition, a visible front panel, indicating lamp shall be provided to monitor power on/off conditions of the pressurization unit.

3.6.4.7 Compatibility.- Each contractor furnished antenna equipment item shall provide a compatible interface to all other contractor furnished equipment items when installed as a system in accordance with the manufacturer's recommendations.

3.6.5 Special tools and test equipment.- The contractor shall supply for each site the special test equipment manufactured expressly for the alignment and maintenance of the RML equipment. Any tools that are required for maintenance or alignment not appearing in GSA Catalog, Part III, Hand Tools, shall be supplied by the contractor for each site.

3.6.6 Standard test equipment.- The contractor shall prepare and forward to the Contracting Officer a comprehensive list of the recommended test equipment and tools required for the maintenance of the microwave link and the ancillary equipment provided under the specification. The list shall itemize all tools and test equipment required for each site, and shall distinguish the test equipment and tools that the contractor proposes to supply under requirements of paragraph 3.6.5.

3.6.7 Net path loss.- For testing purposes, the net path loss shall be adjusted to provide a normal received carrier level of -35 dBm. The net path loss is defined for the purpose of the specification as the total of all losses and gains between the RF subsystem output flange at a transmitting terminal and the input flange of the RF subsystem at the receiving terminal; and include antenna gains, waveguide, and circulator losses external to the RF subsystems, radome losses, and installation and maintenance margins of 3.0 dB. A fade margin of 40 dB shall be added to the net path loss to determine the faded system performance characteristics resulting in a minimum received carrier level of -75 dBm.

The net path loss shall be used by the contractor to establish the RML system performance and shall be used for testing each system at the factory in a standard path configuration. A fade margin of 40 dB shall be added to the net path loss to determine the faded system performance characteristics. A total of 102 dB path loss per hop at any one time shall be used by the contractor for testing the system in a faded condition. Requirements for system testing are included in paragraph 4.0.

3.6.8 Degradation of performance with repeaters.- Input to output performance characteristics as defined in paragraph 3.6.1.2 shall be met with a multihop system of not to exceed a maximum of three repeaters with the following allowed exceptions:

- (a) Low Frequency Response. The departure from horizontal of the top or bottom of a square wave at the field scanning rate shall not exceed  $\pm 1.0\%$  (2% total) of the peak-to-peak amplitude. Refer to paragraph 3.6.1.2.2.3.1.

- (b) High Frequency Response. The transient response as determined by the 1T or T/2 sine-squared pulse and bar signal shall not exceed a K rating factor of 1.5% ( $K = 0.015$ ). Refer to paragraph 3.6.1.2.2.3.2.

Repeater RF equipment shall be identical to terminal RF equipment for maximum interchangeability.

3.7 Reliability/maintainability.- The microwave system shall be designed to meet the following reliability/maintainability requirements.

- (a) The base (no maintenance except in the event of a complete system failure) mean time between failures (MTBF) for the radio equipment only on a single simplex hop shall not be less than 2,000 hours.
- (b) The mean time to repair (MTTR) of a complete simplex radio terminal shall not exceed 30 minutes. No single repair shall take in excess of eight hours.
- (c) The MTTR of a complete, hot stand-by, TML shall not exceed 30 minutes. No single repair shall take in excess of eight hours.
- (d) The mean preventive maintenance time (MPMT) of a complete simplex radio terminal, shall not exceed 30 minutes per 168 hours of operation.
- (e) The MPMT of a complete simplex repeater shall not exceed 30 minutes per 168 hours of operation.

3.7.1 Reliability prediction.- The contractor shall list the MTBF of the various modules/subsystems utilized as part of the equipment design. MTBF figures shall be computed in general consonance with the failure rates, techniques, procedures, etc., of the latest revision of MIL-HDBK-217. The MTBF figures shall be computed at an ambient of +25°C plus the calculated heat rise in the equipment bay. Parts not included in the coverage of the MIL-HDBK-217 shall be assumed to possess the failure rate of the most similar part in the coverage. Where this is unrealistic, any valid existing data may be used, subject to Government acceptance. The module/component MTBF may also be based on existing test data at a 90% confidence level, which has been previously accepted by the Government. Also:

- (a) Each contractor shall compute and list the MTBF of each module, or component if not contained in a module, utilized in his equipment design, as specified above.

- (b) Based on the data obtained in (a) above, the contractor shall predict the number of failures for each below listed subsystem in a one-year period. The contractor shall segregate the number of failures by major type of unit involved.

(1) A complete simplex radio terminal.

(2) A complete simplex repeater.

- (c) Finally, based on the data obtained in (a) and (b) above, the contractor shall calculate, with full calculations being shown, the base MTBF of the following configurations:

(1) Radio equipment only of a single simplex hop (camera site to indicator site).

(2) Radio equipment only of two tandem simplex hops (camera site to repeater station to indicator site).

3.7.2 Reliability program plan.- In addition to the reliability prediction outlined in paragraph 3.7.1 above, an equipment reliability demonstration shall be conducted if required by the contract schedule. Testing of one system shall be according to MIL-STD-781B, test level A-1, test plan IVa (paragraph 4.2.3 of MIL-STD-781B). Sampling reliability tests (paragraph 4.2.4 of MIL-STD-781B) are not required.

3.7.3 Maintainability program.- The required maintainability shall be demonstrated through a maintainability program performed in accordance with the requirements specified herein. The terms and definitions for maintainability not otherwise described in this specification shall be in accordance with MIL-STD-778. All electronic and mechanical equipment and components shall be designed and constructed to minimize skill, experience, and time necessary to disassemble, assemble, and maintain them. Corrective maintenance shall use a remove-and-replace philosophy with actual repair of the replacement module to be accomplished later. The equipment shall meet maintainability parameters in accordance with MIL-STD-470, with the exception of paragraph 5.4a(3). Maintainability demonstrations if ordered, shall be according to MIL-STD-471.

3.7.3.1 Maintainability prediction.- Each contractor shall show the mean time to repair (MTTR) and the mean preventive maintenance time (MPMT) of each of the following subsystems:

- (a) A complete simplex radio terminal.
- (b) A complete simplex repeater.

Both the MTTR and MPMT shall be computed assuming no transportation time, test equipment warm and calibrated, and immediate availability of an operatable spare module to replace any defective unit. The contractor shall provide a complete breakout of the above computations, to demonstrate the logic and basis given for the final figure. Also, the contractor shall state how many men are required to perform the repair actions related to the above MTTR and MPMT figures.

3.7.3.2 Definition of terms.- The terms and conditions of MIL-STD-778 shall apply except as noted below:

- (a) Failure. Any degradation in the performance of an equipment and/or equipment group from the performance requirements stated in this specification.
- (b) Nonrelevant failures. Nonrelevant failures are those failures due to one of the following causes:
  - (1) Failures that result from factors external to the TML. (e.g., a failure in a commercial power system).
  - (2) Failures that result from gross negligence of operating or maintenance personnel.
  - (3) Manufacturing, wiring, or other defects and/or problem areas for which positive corrective action may be initiated, precluding the recurrence of the particular defect.
- (c) Relevant failures. Any failure that does not fall into one of the categories listed under (b) above shall be recorded as relevant failures. Specifically included are failures due to parts defects, degradation due to out-of-tolerance conditions, transients, and unknowns.
- (d) Downtime. Downtime shall include all elapsed time from recognition that a need exists for corrective action to the time that equipment has been repaired, checked out, and is returned to full operational condition, except that downtime does not include:

- (1) Downtime for scheduled preventive maintenance.
  - (2) Downtime caused by nonrelevant failures.
  - (3) Downtime does not include transportation time or test equipment warm-up time, and assumes an operable spare module to replace any defective unit.
- (e) Uptime. Uptime is the total accumulated time during which the on-line and/or off-line equipment group(s) satisfactorily performs its specified functions. Time spent in degraded operation shall not be included as uptime.
- (f) Preventive maintenance downtime. Scheduled downtime to maintain the system in a satisfactory operating condition by providing systematic inspection, detection, and correction of incipient failures, before they occur or develop into major failures. Time to perform on-line system preventive maintenance that does not require interruption or degradation of on-line system performance shall not be considered in the analysis of the off-line equipment parameters.
- (g) Total downtime. Total downtime shall include all elapsed downtime due to failures (d) and all elapsed preventive maintenance downtime (f).

3.7.4 Data analysis equations.- This section presents the equations that shall be used to determine the reliability and maintainability parameters.

- (a)  $MTBF = \frac{\text{Uptime}}{\text{Number of relevant failures}}$
- (b)  $MTTR = \frac{\text{Downtime}}{\text{Number of relevant failures}}$
- (c)  $MPMT = \frac{\text{Preventive maintenance time}}{\text{Uptime} + \text{total downtime}}$
- (d)  $\text{Availability} = \frac{\text{Uptime}}{\text{Uptime} + \text{total downtime}}$

These equations shall be used for both on-line and off-line equipment groups, as applicable, with the parameters reflecting the particular situation.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Quality control program requirements.- The contractor shall provide and maintain a quality control and test program which fulfills the requirements of Federal Aviation Administration Standard FAA-STD-013a, Quality Control Program Requirements. A proposed test plan shall be submitted by the contractor according to paragraphs 2.2.1 and 2.2.2 of FAA-STD-013a, and must include as a minimum the test outlined in the specification. Conditional acceptance of the test plan shall be given so that if, during a test, the test methods or parameters, as agreed to by the Government, are found to be inadequately specified, they will be amended with further approval by the Government required.

4.2 Required tests.- Equipments furnished in accordance with this specification shall be inspected and tested to show compliance with all the requirements of this specification. Five classes of tests are required as follows:

4.2.1 Contractors preliminary tests.- Prior to the time the contractor notifies the Government that the initial production equipment is ready for inspection, and to demonstrate readiness for inspection, he shall make as a minimum one complete set of all tests required by this specification and listed in Table 4.1. These preliminary tests shall be made on one production equipment or on one prototype (preproduction) model. The contractor's preliminary tests do not constitute any of the regular design qualification tests, type tests, or production tests required by the equipment specification.

4.2.1.1 Preliminary test data.- The contractor shall submit to the Government Contracting Officer a certified copy of the test data covering all the contractor's preliminary tests. This test data may be submitted along with the proposed test procedures and forms under FAA-STD-013, but in any case the test data shall be submitted not less than ten workdays in advance of the date set for first inspection and testing.

4.2.1.2 Notification of readiness for inspections.- After submission of the preliminary test data, and when the contractor has one or more pre-production equipments completed, i.e., equipments produced to meet all specification requirements, he shall notify the Government Contracting Officer in writing that he is ready for Government inspection. Such notification shall be given in time to reach the Government Contracting Officer not less than five workdays before the contractor desires inspection to start.

4.2.2 Design qualification tests.- The following design qualification tests shall be performed:

4.2.2.1 Mechanical and visual inspection tests.- The equipment shall be given a thorough mechanical and visual inspection test to verify that the quality of all materials and workmanship are in compliance with the requirements of the specification and as referenced in FAA-G-2100/1b below. Particular attention shall be given to the following:

- (a) Completeness
- (b) Nameplates, identification markings and labels. (1-3.12, 1-3.13, FAA-G-2100/1b)
- (c) Finishes. (3.4.13)
- (d) Fit and placement of components.
- (e) Ease of operation of jacks, switches, gears, adjustable and sliding parts, thumbscrews, and controls.
- (f) Deleted.
- (g) Fastening and securing of parts. (3.4.12)
- (h) Welded and soldered joints. (1-3.10.10.1, FAA-G-2100/1b).
- (i) Wiring and cable runs, including plugs and receptacles. (1-3.10, FAA-G-2100/1b)
- (j) Safety features and interlocks. (3.4.22)
- (k) Grounding connections. (3.4.2)
- (l) Overall dimensions, check for conformance to contractor's specifications. (3.4.14)
- (m) Check of lubrication and rust prevention. (1-3.15.4, FAA-G-2100/1b)
- (n) Visible defects. (3.4.23)
- (o) Accessibility of components and parts for servicing. (3.4.3, 3.4.5)

4.2.2.2 Electrical tests.- The equipment shall be inspected and tested to assure that the wiring is inherently sound and complies with the requirements of the specification. The tests shall include but not be limited to the following:

- (a) All intermodule and rack wiring shall be tested to assure that the wiring is correct and that good electrical contact is obtained.

- (b) AC and DC power distribution cabling shall be inspected to insure that proper overload protection is provided.
- (c) The operating voltages at all important points shall be checked for conformance to the voltages shown on the circuit label and schematic diagrams. This shall be done with all controls set for normal operation of equipment.

4.2.3 Type tests.- The following tests shall be performed by the contractor on a one-time basis to demonstrate compliance with the requirements of this specification:

- (a) Ambient condition performance tests (4.2.3.2).
- (b) Environmental condition performance tests (4.2.3.3).

4.2.3.1 Equipment Arrangement.- The TML equipments shall be configured to provide two radio terminals as required by contract reference to paragraph 3.1.1 (a), (b), (c), (d), or (e) for the first system to be delivered. Testing shall be accomplished using the power supplies required by the contract to be delivered with the equipment.

4.2.3.2 Ambient condition performance tests.- Ambient condition performance tests, shall be conducted as the first step of type testing. Test to be performed shall include, as a minimum, those shown in Table 4.1. Normal factory environment shall be considered ambient conditions.

4.2.3.3 Environmental condition performance tests.- Upon successful completion of ambient condition performance tests (4.2.3.2), the system shall be tested under environmental conditions. Test procedures shall be according to paragraph 1-4.12 of FAA-G-2100/1b and shall determine the equipment capability of operation under the extreme of the service conditions in this specification. Tests to be performed shall include as a minimum those tests shown in Table 4.1.

4.2.4 Production tests.- All equipments supplied under the contract shall be tested individually and as complete systems according to the Government approved, contractor furnished test plan as required in paragraph 4.1 of this specification. Tests to be performed shall include as a minimum those shown in Table 4.1. Complete systems shall consist of both the transmit and receive terminals interconnected with waveguide containing standard path attenuation (3.6.7) and operating with input and output signals as described in paragraph 3.6.1.2. Systems ordered with repeaters, redundant or diversity equipment, or fault alarm remoting shall be tested with all repeaters and subsystems included.

After the contractor has completed all required adjustments to the system, in preparation of demonstrating that the equipment meets all specified performance requirements, and the Government has been notified that the system is ready for the beginning of tests, no further adjustments to the system shall be made until the completion of all the required tests, unless specifically approved and observed by the Government. A record of all such adjustments shall be made a part of the factory system test data. The Government reserves the right to require any retesting deemed necessary to assure that the equipment is meeting all specified performance requirements in the event that equipment adjustments are required after the start of this test.

4.2.5 FCC type acceptance procedures.- All equipments delivered shall meet FCC requirements according to paragraph 1-4.3.5 and 1-4.3.5.1 of FAA-G-2100/1b.

4.2.6 Design Certification.- Specification requirements inherently satisfied by equipment design may be demonstrated by material and component characteristics and/or design calculations in lieu of actual testing. Items requiring design certification include those listed in Table 4.1.

## 5. PREPARATION FOR DELIVERY.

5.1 Packing.- The equipment shall be prepared for delivery in accordance with Specification MIL-E-17555.

## 6. NOTES

6.1 None.-

TABLE 4.1

TEST REQUIREMENTS

Preliminary Tests (4.2.1)

Type Tests (4.2.3)

Production Tests (4.2.4)

Ambient Condition Tests-----X

Environmental Condition Tests (3.5.1)---E

Design Certification (4.2.6)-----D

Characteristic	Preliminary Tests	Type Tests	Prod. Tests	Requirements
Input Power Range	X	X		3.5.2
Transient Protection		X		3.4.10
Alarms	X	X,E	X	3.6.1.1.6
Alarm Remoting (if ordered)	X	X,E	X	3.6.1.1.7
Baseband Input-Output Levels	X	X,E	X	3.6.1.2.2.1
Baseband Frequency Response	X	X,E	X	3.6.1.2.2.3, 3.6.8
Differential Gain	X	X	X	3.6.1.2.2.4
Video Signal-to-Noise	X	X,E	X	3.6.1.2.2.5
Video Signal-to-hum	X	X,E	X	3.6.1.2.2.6
Receiver Quieting Sensitivity	X	X,E	X	3.6.1.2.2.7
Receiver Dynamic Range	X	X		3.6.1.2.2.8
Baseband Variation		E		3.6.1.2.2.9
Transmitter Frequency Stability	X	X,E	X	3.6.2.4, 3.6.1.2.1(b)
Baseband Linearity	X	X		3.6.1.2.2.10
Transmitter Output Power	X	X,E	X	3.6.2.7
Receiver L. O. Stability	X	X,E	X	3.6.3.2
Receiver Noise Figure	X	X,E	X	3.6.3.4

Characteristic	Preliminary Tests	Type Tests	Prod. Tests	Requirements
AFC Capture Range	X	X	X	3.6.3.7
Frequency Tolerance	X	X,E	X	3.6.3.8
Receiver Squelching	X	X,E	X	3.6.3.8
Antenna System	X	X		3.6.4.1.1
Antenna Gain		X	X	3.6.4.1.1
Antenna VSWR		X	X	3.6.4.1.1
Antenna Pattern		X		3.6.4.1.1
Radomes		X		3.6.4.2
Frequency Interface		D		3.6.1.1.1
Frequency Separation		D		3.6.1.1.2
Patch Panel Isolation		D		3.6.1.1.8
Waveguide Switching		D		3.6.1.1.9
Baseband input-output Impedance		D		3.6.1.2.2.1 3.6.1.2.2.2
Transmitter Spurious Emission		D		3.6.2.6
Local Oscillator Leakage		D		3.6.3.5

